SURGICAL APPARELS
COMPARISON OF SOME PHYSICAL PARAMETERS

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ABSTRACT: Background: Around the world, majority of the public and private sector hospitals are using reusable gowns and scrubs whereas only a few hospitals are using disposable ones. Protection during surgery is very important both for the patient as well as for the surgeon. The reasons are not only hygienic but also creating a barrier so that the bacteria and the viruses do not transfer from patient to doctor and vice versa. The surgical gowns have been in use for many decades. With the advancements in the field of manufacturing (weaving and finishing), the quality of gowns has been improving over the period of time. In Pakistan, there is no awareness yet regarding the construction of surgical apparels viz. surgical gowns and scrubs so no standards are being followed as such during the manufacturing (weaving & finishing) of surgical apparels. For effective barrier function of surgical gowns and scrubs, it is necessary for them to comply with certain standards in terms of physical characteristics viz. mass per unit area, number of threads per unit length, tensile strength etc. The idea behind this study was to evaluate the physical characteristics of surgical gowns and scrubs currently being used in different public sector hospitals of Lahore. After which, necessary guidelines can be formulated and proposed to the concerned departments of various hospitals, in the light of which they can design some specifications and select appropriate materials for surgical apparels in future. **Objectives:** 1). To evaluate the physical characteristics of surgical apparels (gowns & scrubs) currently being used in different public sector hospitals of Lahore. 2). Comparison of results with existing/available performance requirements. **Study design:** Experimental study design. **Period:** April 2010-June 2010. **Materials and Methods:** Samples of fabric used for making surgical gowns and scrubs were collected from different hospitals of Lahore and evaluated for different fabric properties viz. mass per unit area, construction analysis (number of threads per unit length) and tensile properties in accordance with EN and ISO standards, in standard atmosphere for testing textiles. **Results and Conclusions:** The results obtained were compared with the available international standards and limited research studies done in the area of surgical apparels yet. It was found that none of the samples collected meet the minimal requirements available yet. So, there is a dire need of some minimal criteria of surgical apparels for the safety of the patients as well as of the health care personnel.

Key words: Surgical apparels, reusable, physical parameters, fabric properties.

INTRODUCTION

Surgical site infections and post-operative infections can result from multiple causes[1]. Over the period of time various developments have been introduced to minimize the infection rate but infection still remains a significant problem despite aseptic techniques/ laminar airflow and peri-operative antibiotics.

There has been concern for transmission of infection from patient to health care personal especially while dealing with HIV and hepatitis patients[2]. Direct contact of body fluids & blood to the skin has been shown to transmit bacterial and viral diseases. Quality of the gowns and other apparels play important role in minimizing such episodes.

Function of the surgical gowns apart from protection, from passage of bacteria and other micro-organisms, is to provide comfort and effective barrier from the environment[3]. For the economic viability, these surgical gowns are preferred to be durable & reusable. Placing high importance on protection, garment and draping materials that allow penetration of infectious body fluids and microorganisms can lead to "strikethrough," contamination, and disease[4].

The main purpose of using gowns and drapes is to prevent the transfer of microorganisms from surgical team and patient's skin to the surgical wound[5].

Surgical gowns are worn in the operating room to reduce the incidence of nosocomial wound infections in patients and to prevent the exposure of medical personnel to pathogens in blood and other body fluids from the patient[6]. Some international organizations like EN have set

standards to define and regulate the function of the surgical apparels.

In Pakistan, no such standards are being regulated or implemented, so it was thought to evaluate the physical characteristics of the surgical gowns and scrubs which are locally fabricated and used in different public sector hospitals and to draw the attention of quality control authorities/regulatory bodies towards this sensitive domain of patient's health care and vice versa.

MATERIALS & METHODS

Representative samples of the surgical gowns and scrubs were collected from five different hospitals of Lahore (Sir Ganga Ram, Jinnah, Lahore General, Mayo & Services Hospital) which were then sorted out into two categories i.e. A and B. A series was designated to surgical gowns while B series to surgical scrubs.

Physical parameters employed to evaluate all the above collected surgical gowns and scrubs were studied under the category of colour fastness properties. In this category, four colour fastness properties were chosen to apply on the surgical gowns and scrubs which are listed below:

1- Colour Fastness to Light: Xenon Arc Fading Lamp Test
2- Colour Fastness to Domestic & Commercial Laundering
3- Colour Fastness to Perspiration
4- Colour Fastness to Rubbing

1- Colour Fastness to Light: Xenon Arc Fading Lamp Test

All the samples of surgical gowns and scrubs were evaluated for colour fastness to light: xenon arc fading lamp test following EN ISO 105-B02:1999[7]. For this purpose, the specimens to be tested along with the references were mounted on two separate white cards and covered one-fifth to one-quarter of the total length of each specimen and reference. The specimens and the references were exposed under the normal conditions (Temperate Zone): moderate effective humidity; colour fastness of the humidity test control: 5; maximum black panel temperature: 55°C. The effect of light was followed by lifting the cover periodically and inspecting the references. When a change in reference 2 was perceived equal to grey scale grade 3, the specimens were inspected and rated their colour fastness by comparing any change that has occurred with the changes that have occurred in references 1, 2 and 3. The first cover was replaced in exactly the same position and continued to expose until a change in reference 4 was perceived equal to grey scale grade 4; at this point second cover was fixed, overlapping the first cover. Exposure was continued until a change in reference 6 was perceived equal to grey scale 4, then the third cover was fixed, the other two covers remaining in position. Exposure was continued until a contrast was produced on reference 7 equal to the contrast illustrated by grey scale grade 4[8].

2- Colour Fastness to Domestic and Commercial Laundering

All the samples of surgical gowns and scrubs were subjected to colour fastness to domestic and commercial laundering following ISO 105-C06(C2S):1994[9]. For this, each specimen of the textile fabric of 100 mm x 40 mm was attached to a piece of the multifibre adjacent fabric, also 100 mm x 40 mm, by sewing along one of the shorter edges, with the multifibre adjacent fabric next to the face side of the specimen. The wash liquor was prepared by dissolving 4g of detergent per liter of distilled water. The washing solution containing perborate was prepared at the time of use by heating the liquor to a maximum temperature of 60°C for not more than 30 min. The pH was adjusted at 10.5 ± 0.1 by the addition of approximately 1 g of sodium carbonate per liter of solution. The liquor was cooled to 20°C before the pH was measured. Wash liquor at a ratio of 50:1 was added to each container and the temperature of the liquor was adjusted at 60 ± 2°C and then each composite specimen was placed in a separate container together with 25 steel balls. The containers were closed and operated the machine at 60°C and for 30 min. The composite specimens were removed at the end of the wash and rinsed twice for 1 min in two separate 100 ml portions of water at 40°C. The excess water was extracted from the composite specimens. The specimens were dried by hanging in air at a temperature not exceeding 60°C, with the parts in contact only in the line of stitching. The change in colour of the specimens and the staining of the adjacent fabrics were assessed using the grey scales[8,10].

3- Colour Fastness to Perspiration

All the samples of surgical gowns and scrubs were evaluated for colour fastness to perspiration following ISO 105-E04:1994[11]. For this, each specimen measuring 100 mm x 40 mm was attached to a piece of the multifibre

adjacent fabric, also measuring 100 mm x 40 mm by sewing along one of the shorter sides, with the multifibre fabric next to the face of the specimen. Each composite specimen was laid out smooth in a flat-bottomed dish and covered with the solution. One composite specimen was thoroughly wet out in the alkaline solution at pH 8 at a liquor ratio of 50:1, and allowed it to remain in the solution at room temperature for 30 min. Pressed and moved it from time to time to ensure good and uniform penetration of the liquor. The solution was poured off and wiped the excess liquor off the specimen between two glass rods then placed the composite specimen between two glass or acrylic resin plates, under a pressure of 12,5 kPa and placed in the test device which had been pre-heated to the test temperature. By the same procedure, one composite specimen was wetted in the acid solution at pH 5.5 and then tested in a separate pre-heated test device. The test devices containing composite specimens were placed in the oven for 4 h at 37°C ± 2°C. Each composite specimen was opened out (by breaking the stitching except on one of the shorter sides) and dried by hanging it in air at a temperature not exceeding 60°C, with the two or three parts in contact only at the line of stitching. The change in colour of each specimen and the staining of the adjacent fabric were assessed with the grey scales[8,10].

4- Colour Fastness to Rubbing

All the samples of surgical gowns and scrubs were characterized for colour fastness to rubbing following EN ISO 105-X12:2002[12]. For this purpose, two pieces not less than 140 mm x 50 mm were required for dry rubbing and two for wet rubbing. One specimen of each pair had the long direction parallel to the warp yarns (or in the direction of manufacture), the other parallel to the weft or filling yarns (or at right angles to the direction of manufacture). Before testing, each specimen and rubbing cloth was conditioned for at least 4 h in the standard atmosphere by laying each test specimen and each piece of rubbing cloth separately on a screen or perforated shelf[13]. Each test specimen was fastened by means of clamps to the baseboard of the testing device so that the long direction of the specimen follows the track of the device. Between the baseboard of the testing device and the specimen, a piece of soft back waterproof abrasive paper was placed.

Dry rubbing. The conditioned rubbing cloth was placed, flat over the end of the finger with the weave parallel to the direction of rubbing finger. At a rate of 1 cycle per second rubbed to and fro in a straight line 20 times, 10 times to and 10 times fro, along a track 104 3 mm long on the dry specimen with a downward force of 9 0.2 N. Any extraneous fibrous material was removed that might interfere with the rating.

Wet rubbing. A rubbing cloth was prepared by weighing a conditioned piece of cloth, then thoroughly soaked in distilled water and re-weighed to ensure take-up of 95-100 %. The instructions for rubbing were followed as described above. The test cloth was then air-dried. Each

tested rubbing cloth was backed with three layers of white rubbing cloth while evaluating. The staining of the cotton rubbing cloths was assessed with the grey scale for staining under suitable illumination[10].

DISCUSSION

When the colour fastness to light of surgical gowns (1-A to 5-A) was compared, it was observed that most of the samples showed good rating i.e. 6 to 6-7. On comparing the colour fastness to light of surgical scrubs (1-B to 5-B), it was found that 4-B and 5-B showed intermediate ratings i.e. 4 to 5 whereas 1-B, 2-B and 3-B showed poor ratings i.e. 3 to 3-4.

When the colour fastness to domestic and commercial laundering of surgical gowns was compared, it was found that in staining most of the samples of surgical gowns (1-A

RESULTS

Table-1: Colour Fastness to Light: Xenon Arc Fading Lamp Test

Sample Code	Change in Colour according to Blue Scale
1-A	6-7
2-A	6
3-A	6-7
4-A	6-7
5-A	6
1-B	3
2-B	3-4
3-B	3
4-B	5
5-B	4

Table-2: Colour Fastness to Domestic and Commercial Laundering

Sample Code	Staining Grade						Colour Change
	Acetate	Cotton	Nylon	Polyester	Acrylic	Woo	Grade
1-A	3-4	4	4	4	4-5	4	3-4
2-A	3	4-5	4	4-5	4-5	4-5	4
3-A	3-4	4	4	4	4	4	4
4-A	3-4	4	3-4	4	4	4	4
5-A	4	4-5	4	4	4-5	4	4
1-B	4-5	3-4	4-5	4-5	4-5	4-5	4
2-B	3-4	2-3	2-3	4	4-5	4	3-4
3-B	4-5	3-4	4-5	4-5	4-5	4	4
4-B	4	3	3-4	4-5	4-5	4	4
5-B	4	4	3	4-5	4-5	4	4

Table-3: Colour Fastness to Perspiration

Acidic

Staining Grade Sample Code							Colour Change Grade
	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool	
1-A	5	5	5	5	5	4-5	4-5
2-A	5	5	5	5	5	5	5
3-A	5	5	5	5	5	5	5
4-A	5	5	4-5	5	5	5	4-5
5-A	4-5	4-5	4-5	4-5	4-5	4-5	4-5
1-B	4-5	3-4	4-5	4-5	4-5	4-5	4-5
2-B	4-5	2-3	2	4	4	4	4-5
3-B	4-5	3-4	4	4-5	4-5	4-5	4-5
4-B	3-4	2	2-3	3-4	4	4	4-5
5-B	4-5	4-5	4	4-5	4-5	4	4-5

Alkaline

Sample Code	Staining Grade						Colour Change
	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool	Grade
1-A	5	5	5	5	5	4-5	4-5
2-A	4-5	5	5	5	5	4-5	4-5
3-A	4-5	5	5	5	5	4-5	4-5
4-A	4-5	5	5	5	5	4-5	4-5
5-A	5	5	5	5	5	4-5	4-5
1-B	4-5	3	4-5	4-5	4-5	4-5	4-5
2-B	4	2-3	2	4	4	3-4	4-5
3-B	4-5	4	4-5	4-5	4-5	4-5	4-5
4-B	3-4	2	2-3	3	4	4	4-5
5-B	4-5	4-5	4	4-5	4-5	4-5	4-5

1-A = Sir Ganga Ram Hospital (Surgical Gown)
2-A = Jinnah Hospital (Surgical Gown)
3-A = Lahore General Hospital (Surgical Gown)
4-A = Mayo Hospital (Surgical Gown)
5-A = Services Hospital (Surgical Gown)
1-B = Ganga Ram Hospital (Surgical Scrub)
2-B = Jinnah Hospital (Surgical Scrub)
3-B = Lahore General Hospital (Surgical Scrub)
4-B = Mayo Hospital (Surgical Scrub)
5-B = Services Hospital (Surgical Scrub)

to 5-A) showed good ratings i.e. 4 to 4-5 and some showed intermediate ratings i.e. 3 to 3-4. Whereas in colour change all the samples of surgical gowns (1-A to 5-A) showed good rating i.e. 4 except 1-A which showed intermediate rating i.e. 3-4. On comparing the colour fastness to domestic and commercial laundering of surgical scrubs, it was observed that in staining most of the samples (1-B to 5-B) showed good ratings i.e. 4 to 4-5, some showed intermediate ratings

Table-4: Colour Fastness to Rubbing

Sample Code	Dry Crock Staining Grade		Wet Crock Staining Grade	
	Dry Crock Rating Warp	Dry Crock Rating Weft	Wet Crock Rating Warp	Wet Crock Rating Weft
1-A	4-5	4-5	3	3
2-A	4	4	2	2
3-A	4	4-5	2-3	2-3
4-A	4-5	4-5	4	3-4
5-A	4-5	4-5	3-4	4
1-B	4-5	4-5	3-4	3-4
2-B	4-5	4-5	3-4	3-4
3-B	4-5	4-5	4	4
4-B	4-5	4-5	4	3-4
5-B	4-5	4-5	4	4

i.e. 3 to 3-4 and few showed poor rating i.e. 2-3. Whereas in colour change all the samples of surgical scrubs (1-B to 5-B) showed good rating i.e. 4 except 2-B which showed intermediate rating i.e. 3-4.

When the colour fastness to acidic perspiration of surgical gowns was compared, it was found that all the samples of surgical gowns (1-A to 5-A) showed good rating both in staining and colour change i.e. 4-5 to 5. Whereas when the colour fastness to acidic perspiration of surgical scrubs (1-B to 5-B) was compared, it was observed that in colour change, all the samples of showed constant rating i.e. 4-5. But in staining, most of the samples showed good rating i.e. 4 to 4-5, some showed intermediate rating i.e. 3-4 and few showed poor rating i.e. 2 to 2-3.

When the colour fastness to alkaline perspiration of surgical gowns was compared, it was found that all the samples of surgical gowns (1-A to 5-A) showed good rating both in staining and colour change i.e. 4-5 to 5. Whereas when the colour fastness to alkaline perspiration of surgical scrubs (1-B to 5-B) was compared, it was observed that in colour change all the samples of scrubs showed constant rating i.e. 4-5. But in staining, most of the samples showed good rating i.e. 4 to 4-5, some showed intermediate rating i.e. 3 to 3-4 and few showed poor rating i.e. 2 to 2-3.

When the colour fastness to rubbing of surgical gowns (1-A to 5-A) was compared, it was observed that in dry crock staining most of the samples showed good rating i.e. 4 to 4-5 whereas in wet crock staining some samples showed good rating i.e. 4, some showed intermediate rating i.e. 3 to 3-4 and some showed poor ratings i.e. 2 to 2-3. On comparing the colour fastness to rubbing of surgical scrubs (1-B to 5-B), it was found that in dry crock staining all the samples showed constant rating i.e. 4-5 whereas in wet crock staining some showed good rating i.e. 4 and some showed intermediate rating i.e.3-4.

Colour fastness against various agencies viz. light, domestic & commercial laundering, perspiration and rubbing etc. depicts the dye fastness of surgical apparels (gowns and scrubs) from which they are dyed of. Analyzing colour fastness to all the aforementioned agencies, it was found that all the collected specimens of gowns and scrubs did not meet any uniform criteria and faded to different extents in response to exposure to these agencies. This signifies the irregular pattern of quality & degradation of these apparels to natural elements and physical inability to withstand during daily wear and tear.

As outlined in the beginning of this article, the important function of surgical apparels is protection of health personnel form the environment which is full of pathogens in adverse conditions[14]. At the same time, these gowns/apparels need to be comfortable, durable, reusable and economically viable as compared to the single use/disposables ones. The main purpose in using gowns and drapes is to prevent the transfer of microorganisms from the surgical team and patient's skin to the surgical wound.

Quality of fabric used in surgical apparels is very important for its longevity and ability to be used again and again. Random pattern of quality of fabrics which is reflected in various colour fastness properties viz. colour fastness to

light, domestic & commercial laundering, perspiration and rubbing results in early wear and tear which produces various defects including asymmetrical and unequal wear and thinning[15]. These parameters have immense impact in disease transmission to health personnel as worn fabrics allow failures of function of impermeability and at the same time also result in economical loss as they need to be replaced earlier than anticipated.

The most important function of any surgical apparels is its resistance against permeability to aqueous solutions and body fluids as these fluids are easy conduit for bacterial and viral transmission from one person to another, from patient to surgeon and vice versa.
Poor physical characteristics will render these fabrics and apparels susceptible to easy and early wear and tear and thus making fluid transmission across the surgical apparels very easy: hence increasing the risk of infection and disease transmission.

It is recommended that these apparels should be made of such fabric/material which meet certain minimum standards and requirements and at the same time be reusable and economical.

CONCLUSIONS

To control infection in surgical patients, aseptic measures taken do reduce the risk to significant level. Next very important and attention seeking area is good quality apparels which should be colour fast, strong, comfortable and resistant to medical aqueous solutions and body fluids. None of our collected samples display a uniform pattern in colour fastness properties. Quality control authorities/regulatory bodies must develop some criteria regarding colour fastness properties of surgical apparels and establish some performance specifications of surgical apparels & drapes (reusable & disposable) on the lines of international organizations currently working on this issue and should also play a key role in the implementation of these standards in public and private sector hospitals.

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